

DOCUMENT RESUME

ED 212 234

HE 014 735

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TITLE Correlates of Performance in the Dental Hygiene Program.
INSTITUTION Minnesota Univ., Minneapolis. Office for Student Affairs.
PUB DATE 11 Nov 81
NOTE 22p.
JOURNAL CIT OSA Research Bulletin; v22 n5 Nov 11 1981

EDRS PRICE MF01/PC01 Plus Postage.
DESCRIPTORS *Admission Criteria; *Allied Health Occupations Education; College Admission; *Dental Hygienists; Grade Point Average; Higher Education; Multiple Regression Analysis; *Performance Factors; *Predictor Variables; Standardized Tests; State Universities

IDENTIFIERS Institutional Research; *University of Minnesota

ABSTRACT

The effectiveness of measures used in the admissions process to predict performance in and/or graduation from a University of Minnesota dental hygiene program is examined. Students in classes entering from Fall 1977 through Winter 1979 were studied, and predictor and performance measures to be studied were identified by the program. Predictor measures included American College Testing Program scores in English, mathematics, social science, natural science, and the composite score; age; Dental Hygiene Aptitude Test score; high score percentile rank and class size; Minnesota Scholastic Aptitude Test score; high school natural science credits and grade point average (GPA); college GPA; and Preliminary Scholastic Aptitude Test scores. Performance measures include national board test score; a course completion index; overall GPA; measure of dental hygiene program completion; and college life science GPA. Correlations between predictor and performance variables were analyzed, and predictors not meeting pre-established criteria were eliminated. Chosen performance measures were analyzed with their valid correlating predictor measures in stepwise multiple regression. Three potentially useful regression equations resulted: two predicted GPA and one predicted a dichotomous variable indicating success or failure in the program. A discussion of a possible seven-step admission procedure using both clinical and statistical approaches is presented. (Author/MSE)

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ED212234

OSA Research Bulletin
Office for Student Affairs

University of Minnesota

Volume 22

Number 5

Date November 11, 1981



Correlates of Performance in the Dental Hygiene Program,
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Abstract

This study examines the effectiveness of measures used in the admissions process to predict performance in and/or graduation from the Dental Hygiene Program. Students in classes entering from fall 1977 through winter 1979 were studied. Predictor and criterion, or performance, measures to be studied were identified by the Program. Correlations between predictor and performance measures were analyzed. Predictor measures not meeting pre-established criteria were dropped from further analysis. Inter-correlations of performance measures were analyzed and the most suitable measures were selected for further analysis. Chosen performance measures were analyzed with their valid correlating predictor measures in a stepwise multiple regression. Three potentially useful regression equations resulted; two predicted GPA, and one predicted a dichotomous variable indicating success or failure in the program. A discussion of a possible seven-step admission procedure using both clinical and statistical approaches was presented.

The Dental Hygiene Program at the University of Minnesota is a two-year undergraduate program leading to the Graduate Dental Hygienist degree. Like many other upper division programs, applicants to the Program are evaluated primarily on the basis of their previous college work. In any given year, about two applicants are reviewed for each admitted student; that is, the selection rate is about 50%.

In recent years, there has been increasing concern about admissions criteria and strong interest in determining whether the criteria used are valid (i.e., predict success or failure in the program). Many colleges and programs at the University have recently reviewed their admissions processes, with the goal of better understanding the correlates of success and establishing valid admissions criteria.

The Admissions and Records Data Retrieval Center was contacted by the Program in Winter 1980 and asked to assist in studying the admissions process, both in terms of the admissions criteria in use (basically a previous college GPA of 2.00 or higher) and in terms of other potential admissions criteria. Staff members in the Program worked closely with DRC staff in collecting data for the study (much of which was not available in computer files) and in planning what was to be studied; DRC staff were responsible for writing the required computer programs and doing the needed data analyses.

It is hoped that this report will stimulate discussion about the admissions criteria in use and facilitate decision making about changes in the criteria, if any seem warranted.

METHOD

Sampling

In the selection of the sample population, two criteria were used. First, the sample had to be as recent as possible, so as best to reflect trends in test scores, grades, etc. Secondly, a large enough sample was needed to adequately determine the relationship between measures. On the basis of these criteria four entering classes were selected: Fall Quarter 1977, Winter Quarter 1978, Fall Quarter 1978, and Winter Quarter 1979.

If the dental hygiene program were completed on schedule, students would graduate two years from the quarter of entry. The anticipated graduation dates were August 1979, December 1979, June 1980, and December 1980, respectively. The number of students in each class was 65, 67, 56, and 51 respectively, for a total sample size of 239 students. All of the students were female.

Procedure

The Dental Hygiene Program identified the predictor and performance measures to be considered in the study. These measures are given in Table 1. Upon selection of the measures, data for the four classes were obtained from three System 2000 Student Data Bases operated by the Admissions and Records Data Retrieval Center, and from Program records. In addition, the data for twelve students not found in any of the Student Data Bases were obtained from individual transcripts and 'pockets' of applicant information. An SPSS¹ system file was created from the data, and computations and statistical analysis were done with SPSS Online Version 8.0 on the University Computer Center Cyber 172 computer.

¹ Statistical Package for the Social Sciences

Table 1

PREDICTOR MEASURES

Measure name	Measure description
ACTE	American College Testing Program English score
ACTM	American College Testing Program Mathematics score
ACTSS	American College Testing Program Social Science score
ACTNS	American College Testing Program Natural Science score
ACTCOMP	American College Testing Program Composite score
AGE	Age of student as of January 1, 1980
DHAT	Dental Hygiene Aptitude Test
HSRANK	High school percentile rank
HSSIZE	High school class size
MSAT	Minnesota Scholastic Aptitude Test score
NSCREDIT	Number of natural science credits taken in high school
NSGPA	High school natural science grade point average
PCGPA	Previous college grade point average
PSATV	Preliminary Scholastic Aptitude Test-Verbal score
PSATM	Preliminary Scholastic Aptitude Test-Mathematic score
PSATMEQ	PSAT Mathematics score or equivalent derived from ACT Mathematics score

PERFORMANCE MEASURES

Measure name	Measure description
BOARD	National board test score
CC	Coefficient of Completion (credits completed divided by credits attempted)
GPA	Grade point average (for all coursework taken at the U of M)
PROGCOM	Measure of Dental Hygiene Program completion (1 = complete, 0 = did not complete)
SCIGPA	U of M life science GPA (biology, anatomy, and physiology)

In addition to the measures selected by the Dental Hygiene Program, a PSAT math equivalency score was created. This score was the PSAT math score for those students who had taken the test, or an equivalent score for those students who had only ACT math scores. The Minnesota Higher Education Coordinating Board ² found that PSAT math scores were related to ACT math scores according to the equation

$$\text{PSAT math} = 1.56 (\text{ACT math}) + 15.62$$

The value derived from this equation was called PSATMEQ.

The mean, standard deviation, and number of cases used for each measure are given in Table 2.

The determination of a 'success predictor' involved essentially three steps. In the first step, correlations between predictor and performance measures were analyzed. The predictor measures not meeting pre-established criteria were dropped from further analysis. In the second step, intercorrelations of performance measures were analyzed and the most suitable measures were selected for further analysis. In the final step, the chosen performance measures were analyzed with their valid correlating predictor measures in a stepwise multiple regression.

Description of statistics used. Correlation is the co-relation between variables or properties represented by the variables. In general, two variables correlate linearly and positively when, as the value of one variable increases, the paired values of the other variable increase correspondingly. Although there are several measures of correlation, one commonly used, and used in this study, is the Pearson product-moment correlation coefficient. This measure

²Perry, Dallis. Minnesota score -- ACT score correspondence (MPSPP Technical Report No. 3). Minneapolis, MN: Minnesota Higher Education Coordinating Board, Minnesota Post-High School Planning Program, August 1979.

Table 2
DESCRIPTIVE STATISTICS

Dental Hygiene Program Students
entering Fall 1977, Winter 1978, Fall 1978, and Winter 1979

Measure name	Mean	Standard deviation	N
PREDICTOR MEASURES			
ACTE	20.5	3.3	84
ACTM	20.4	5.6	84
ACTSS	20.1	5.6	84
ACTNS	24.4	4.1	84
ACTCOMP	21.6	3.4	84
AGE	22.3	3.6	233
DHAT	4.87	1.11	237
HSRANK	83.6	11.7	144
HSSIZE	411	211	129
MSAT	65.3	22.4	28
NSCREDIT	1.79	.67	146
NSGPA	3.15	.60	146
PCGPA	3.05	.41	110
PSATV	43.0	7.1	125
PSATM	49.2	6.5	125
PSATMEQ	48.6	6.7	168
PERFORMANCE MEASURES			
BOARD	87.5	4.9	198
CC	.937	.147	168
GPA	2.95	.47	233
PROGCOM ^a	-	-	239
SCIGPA	2.53	.67	55

^a203 completed the program, 36 did not.

varies between +1.00 and -1.00. The sign of the coefficient indicates whether the correlation is positive or negative. A coefficient of +1.00 indicates a perfect positive linear correlation; that is, knowledge of one score enables one to predict its correlate without error and high scores on one correlate are related to high scores on the other. A coefficient of -1.00 indicates a perfect negative linear correlation; that is, one can predict one correlate from the other without error and high scores on one correlate are related to low scores on the other. A coefficient of zero indicates the total absence of any linear relation between two variables. Pearson's coefficient is represented by the letter r.

If we square r we get another statistic, denoted r². Actually r² is a more easily interpreted measure of association when our concern is with strength of relationship rather than direction of relationship. It is a measure of the proportion of variance in one variable 'explained' by the other. r² ranges from 0.00 to 1.00.

Multiple regression is a statistical technique through which one can analyze the relationship between a performance measure and a set of predictor measures. The strength of these relationships is measured by the multiple correlation coefficient R, and its counterpart R², which are analogous to r and r². A statistic that measures the absolute amount of explained or unexplained variation is the standard error of estimate. This statistic is the standard deviation of actual performance measure values around the predicted performance measure values and is denoted SEE.

The significance of relationships was measured by the Student's t statistic in the case of Pearson coefficients, and by the F statistic in the case of multiple regression. The significance (p) ranges from 0.00 to 1.00, and measures the probability that no relation exists between the variables con-

cerned. For example, $p = .05$ means that there are 5 chances in 100 that there is no relationship between variables.

In the first two steps relationships with correlations of .20 or higher (4% or more of the proportion of variance in the performance measure is explained by the predictor measure) and a significance level of .05 or lower (5% or less chance that there is no relationship between the predictor and performance measures) were selected for further analysis. In addition the n (number of cases) was also considered. Those relationships between predictor and performance measures involving fewer than 100 cases were eliminated from further analysis.

In the multiple regression step, predictor sets had to reach a significance level of .05 or lower. In addition, relationships were expected to have at least 50 cases per variable in the predictor set, so as to adequately measure the nature and strength of the relationship. The predictor set with the highest correlation with the performance measure, providing it met the criteria, was chosen as the 'success predictor.'

RESULTS

Correlations Between Predictor and Performance Measures

The Pearson coefficients of the performance measures by the predictor measures meeting the criteria described in the previous section, along with the number of cases are given in Table 3. Special note should be taken of the number of cases included in each Pearson coefficient calculation. Owing to missing data, only the correlation between U of M GPA and the Dental Hygiene Admissions Test includes more than 200 of the 239 cases. The Minnesota Scholastic Aptitude Test has a particularly small number of cases used in evaluating the relationship. Due to the n and the fact that the Minnesota Scholastic Aptitude Test is no longer administered, the MSAT measure was dropped from further analysis.

Correlations Among Performance Measures

The intercorrelations of the performance measures are shown in Table 4. Each of the performance variables measure 'internal success'; that is, they show how the students in the program do with respect to each other. They do not necessarily measure 'external success,' or how the students will do once they become dental hygienists. However, the measure PROGCOM does determine whether or not the students become licensed dental hygienists. (PROGCOM is a measure of those who completed the dental hygiene program. Students completing the program were given a score of 1. Students not completing the program were given a score of 0.) In a sense, PROGCOM is a measure of 'external success', and so two multiple regressions are suggested; namely, one with a performance measure of 'internal success' and one with the performance measure of 'external success'.

Table 3

Correlation of Predictor Measures with Performance Measures

Predictor/ abbreviation	Performance measure				
	National board scores (BOARD)	U of M GPA (GPA)	College science GPA (SCIGPA)	Coefficient of completion (CC)	Completion measure (PROGCOM)
ACT English (ACTE)	.383 N(62)				
ACT Mathematics (ACTM)			.323 N(27)	.371 N(56)	
ACT Social Studies (ACTSS)	.296 N(62)				
ACT Natural Science (ACTNS)				.273 N(56)	
ACT Composite (ACTCOMP)	.333 N(62)			.276 N(56)	
Age as of 1/1/80 (AGE)					
Dental Hygiene Aptitude Test (DHAT)	.287 N(197)	.212 N(231)			
High school rank (HSRANK)	.301 N(114)	.244 N(138)	.395 N(44)	.272 N(105)	
High school class size (HSSIZE)			.373 N(32)		
Minnesota Scholastic Aptitude Test (MSAT)	.423 N(25)	.537 N(28)			.403 N(28)
Natural science credits (NSCREDIT)					
Natural science GPA (NSGPA)				.417 N(108)	.213 N(146)
Previous college GPA (PCGPA)		.283 N(105)			
PSAT Verbal (PSATV)					
PSAT Mathematics (PSATM)				.322 N(86)	.235 N(125)
PSAT Math equivalency score (PSATMEQ)		.232 N(162)		.311 N(117)	.258 N(168)

NOTE. Only those correlations meeting the following criteria are listed:
Correlation $\geq .20$ and significance $\leq .05$.

Table 4
Intercorrelations of Performance Measures

Performance measure/abbreviation	Board	GPA	SCIGPA	CC	PROGCOM
National Board Scores (BOARD)	--				
Univ of Minn GPA (GPA)	.563 N(197) p=.000	--			
College Science GPA (SCIGPA)	.363 N(46) p=.006	.711 N(55) p=.000	--		
Coefficient of Completion (CC)	.089 N(147) p=.142	.543 N(165) p=.050	.375 N(34) p=.014	--	
Completion of DH Program (PROGCOM)	a	.372 N(233) p=.000	.309 N(55) p=.022	.634 N(168) p=.000	--

NOTE. Total N possible = 239. p is the significance or probability that there is no relationship.

^aNo nongraduates had National Board scores, so this correlation is impossible to measure.

Since there are four performance measures of internal success (National Board Scores, U of M GPA, Science GPA, and Coefficient of Completion), some determination needs to be made of which is the "best." Examination of the correlations between the individual performance measures shows that U of M GPA has the highest overall correlation with the other measures.

Multiple Regression Analysis

The results of a stepwise multiple regression done with U of M GPA as the dependent variable and the previous college GPA, high school rank, Dental Hygiene Aptitude Test, and PSAT math equivalent in various predictor combinations is shown in Table 5. The multiple correlation coefficient (R) is shown, as well as the variance (R^2), the standard error of estimate (SEE), and the number of cases included in the determination of the relationship (N).

Regression analysis based on fewer than 100 cases for predictor sets with two independent variables is of questionable validity. This eliminates previous college GPA + high school rank, previous college GPA + PSAT math equivalent, and previous college GPA + high school rank + PSAT math equivalent from further consideration, in spite of the fact that the correlation coefficients for those three predictor sets are relatively high. In addition the predictor set high school rank + PSAT math equivalent + Dental Hygiene Aptitude Test has fewer than 50 cases per independent variable. For the purpose of this study, this eliminates this predictor set from further consideration.

The predictor set that gives the highest correlation coefficient, meeting the criteria, is then high school rank + Dental Hygiene Aptitude Test. The regression equation for this combination is

$$\text{GPA} = .0936(\text{DHAT}) + .00814(\text{HSRANK}) + 1.76$$

Table 5
Correlation of Predictor Measure Sets with GPA

Predictor sets/abbreviation	Statistics			
	R	R ²	SEE	N
Previous college GPA (PCGPA)	.283	.080	.450	105
High school rank (HSRANK)	.244	.059	.464	138
PSAT Math equivalent (PSATMEQ)	.232	.054	.476	162
Dental Hygiene Aptitude Test (DHAT)	.212	.045	.455	231
PCGPA + HSRANK	.750	.563	.383	29
PCGPA + PSATMEQ	.426	.182	.478	51
PCGPA + HSRANK + PSATMEQ	.769	.592	.382	23
PCGPA + DHAT	.276	.076	.452	104
HSRANK + PSATMEQ	.295	.087	.461	127
HSRANK + DHAT	.304	.093	.451	136
HSRANK + PSATMEQ + DHAT	.323	.104	.452	125
PSATMEQ + DHAT	.290	.084	.465	160

NOTE. Significance for all correlations is less than or equal to .05.

For those students who may have taken the ACT or PSAT tests and not the Dental Hygiene Aptitude Test, the predictor set involving high school rank and the PSAT math equivalent yields a correlation that is almost as high as the predictor set involving high school rank and Dental Hygiene Aptitude Test. The equation for this measure is

$$\text{GPA} = .0143(\text{PSATMEQ}) + .00775(\text{HSRANK}) + 1.55$$

The results of a multiple regression done with PROGCOM as the dependent variable and PSAT math, PSAT math equivalent, and high school natural science GPA in various predictor combinations are shown in Table 6. In addition to Pearson's coefficient, Pearson's coefficient squared, the standard error of estimate, and the number of cases included for each predictor set, the ratio of nongraduates to graduates is given. In the total sample there were 36 nongraduates and 203 graduates for a ratio of .117. As Table 6 reveals, the predictor sets each have a greater proportion of nongraduates than does the sample as a whole.

Although natural science GPA + PSAT math gives the highest correlation coefficient, the inadequate number of cases eliminates it from further consideration in this study. The combination natural science GPA + PSAT math equivalent is then the preferred predictor set. The equation for this predictor set is

$$\text{PROGCOM} = .0153(\text{PSATMEQ}) + .0912(\text{NSGPA}) - .217$$

Table 6
Correlation of Predictor Measure Sets with PROGCOM

Predictor sets	R	R ²	SEE	N	Ratio of nongrads to grads
PSAT math equivalent (PSATMEQ)	.258	.067	.377	168	.226
PSAT math (PSATM)	.235	.055	.359	125	.190
Natural Science GPA (NSGPA)	.213	.046	.371	146	.207
NSGPA + PSATM	.435	.189	.344	94	.205
NSGPA + PSATMEQ	.336	.113	.370	135	.227

NOTE. Maximum N possible = 239 (36 nongraduates and 203 graduates). Significance for all correlations is less than or equal to .05.

DISCUSSION

In doing this study several difficulties became apparent. One was in the homogeneity of the data. This was because the students in the sample had already been selected from an applicant pool on the basis of their estimated likelihood of success in the dental hygiene program. As a result, the predictor and performance measures tend to be restricted in range. This would cause the relationship between indicator and performance measure to be less apparent; hence, low correlations.

Another difficulty in this study was the large amount of missing data. Many of the measures had values for only half or fewer of the 239 cases, sometimes reducing the usable N to the point where useful inferences can't be made. In an attempt to increase the N for a promising measure, the PSAT math equivalent was created from a combination of PSAT math and ACT math. (These two tests measure the same ability in students, and so their scores can be equated to a large degree.)

Yet when working with N's as small as were used here, even one case can have a dramatic effect on the data. This is illustrated in Table 4, where the Dental Hygiene Aptitude Test measure is added to the previous college GPA to form a predictor set for U of M GPA. Since both measures correlate positively with U of M GPA, one would expect the combination to have a higher correlation with U of M GPA than the individual measures. However, this is not the case. Due to the elimination of one case because of missing data, the correlation of the predictor set is reduced to .276 from the correlation of .283 previous college GPA has with U of M GPA.

As a result of the small N involved in regression analysis, predictor sets with a combination of previous college GPA and high school rank were unusable, as were predictor sets with more than two variables. Although correlations

involving previous college GPA and high school rank were high, there is no assurance that these relationships would be maintained if the missing data were collected. A comparison of zero order correlations with U of M GPA for the entire sample and for the subgroup having values for both previous college GPA and high school rank is given in Table 7. It should be noted that for subgroup the correlations involving high school rank and PSAT math equivalent are more than 50% greater than the entire sample, and the correlation involving previous college GPA is more than twice as high. This subgroup, then, appears to be atypical of the population in general. Going through the time consuming process of obtaining both high school rank and previous college GPA for all students would be unlikely to produce results on the level indicated by the subgroup.

The differentiation of the measures of internal and external success is weak at best. PROGCOM is a measure of internal success. (Though with its dichotomous nature, it determines who will be eligible for external success.) If PROGCOM is to be evaluated along with the other measures of internal success, U of M GPA still remains the most predictable performance measure.

Before drawing any conclusions from these results, one must note that they were achieved by applying the regression weights to data from the same sample on which the weights were developed. Some of the variation accounted for is likely to prove specific to this particular sample. Therefore, when the weights are applied to another set of scores, some reduction in the size of R is likely to occur. The net improvement in prediction may not even be as large as this analysis indicated.

TABLE 7

Correlation of GPA with Selected Predictor Measures
for entire Sample and Subgroup with HSRANK and PCGPA

	Entire sample	Subgroup with values for both HSRANK & PCGPA
DHAT	.212 N(231) p=.001	.207 N(28) p=.145
HSRANK	.244 N(138) p=.002	.463 N(29) p=.006
PCGPA	.283 N(105) p=.002	.668 N(29) p=.000
PSATMEQ	.232 N(162) p=.002	.428 N(23) p=.021

NOTE. Total N possible for entire sample is 239. Total N possible for subgroup is 29. p is the significance or probability that there is no relationship.

SUMMARY AND RECOMMENDATIONS

At the request of the Dental Hygiene Program, the A&R Student Data Retrieval Center undertook a study of the Program's 1977 and 1978 entering classes. The purpose of the study was validation of the current admissions criteria based on previous college grade point average and the study of other possible predictor and criterion measures.

Predictor measures studied included: ACT scores, age, Dental Hygiene Aptitude Test scores, high school class size, high school rank, Minnesota Scholastic Aptitude Test score, a math ability measure formed by using either the PSAT math or ACT math score, PSAT verbal, PSAT math, high school natural science credits, and previous college grade point average. Criterion, or performance, measures included a dichotomous variable indicating success or failure in the Program, GPA, coefficient of completion, national board test score, and life sciences GPA at the University.

Correlations between and among the predictor and performance measures were studied, followed by a multiple regression analysis. The results of these analyses suggest that of the performance measures, the GPA and program completion measure had the strongest relationship to the predictors; among the predictors, high school rank, the math ability measure, previous college GPA, and natural science GPA show the most promise.

Three regression equations were presented, two which predict GPA and one which predicts program completion:

$$\text{Formula 1 } \text{GPA} = .0936(\text{DHAT}) + .00814(\text{HSRANK}) + 1.76$$

$$\text{Formula 2 } \text{GPA} = .0143(\text{PSATMEQ}) + .00775(\text{HSRANK}) + 1.55$$

$$\text{Formula 3 } \text{PROGCOM} = .0153(\text{PSATMEQ}) + .0912(\text{NSGPA}) - .217$$

A discussion of problems with the data (inadequate N; restriction of range, lack of cross validation) was presented and suggested caution in immediate application of these formulae to decision making.

If a new procedure were desired at this time, the following might be done:

1. Establish the desired size of the entering class.
2. Calculate the value of predicted GPA using formula 1 and formula 2, if possible, for each student.
3. Arrange these predicted GPAs in descending order, one distribution based on each formula.
4. Establish a cutting score for each predicted GPA such that more students than desired in the class would be selected if that criterion were being used (e.g., 25% more than desired, although the percentage is somewhat arbitrary).
5. Select an applicant for inclusion in the final selection process if he or she meets or exceeds the cutting score on either measure.
6. Examine records of these finalists to assess other relevant measures (e.g., minority status, previous institution attended, type of college work done so far, etc.).
7. Make final decisions to fill the class.

This procedure is basically one of selecting an applicant pool using statistical, data-oriented procedures, and then of using clinical measures in the final process. The purpose of using both formulae is to restrict measurement error somewhat (i.e., give the student the benefit of the doubt). The same reason underlies overselecting students for the applicant pool. Making selections solely on the basis of the predicted GPA is unwarranted by the data presented here. An alternative approach, similar to the above, would select some students for automatic admission based solely on a high predicted GPA, but would still

review a considerable number of student files below that cutoff; this approach is similar to that used today by many University of Minnesota colleges.

One question raised by the Program was whether or not the Dental Hygiene Aptitude Test could be dropped from use. The answer is a qualified yes. The DHAT and PSAT math equivalent scores are correlated around .52, which indicates that to some extent they measure the same thing. This relationship is not perfect, however; only about 27% of their variance is in common. Both correlate with U of M GPA to approximately the same degree. So, if a selection procedure was used which was not too rigid in its reliance on predicted GPA, the DHAT could probably be dropped.